



# FRA Step 4 Tree and Shrub Species Selection for Reforestation of Reclaimed Mineland



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# Historical Perspective

- Reclamation mid 20th century:
  - Reclamation synonymous with reforestation
  - 1941 state law required tree planting



# Historical Perspective

- Reclamation mid 20th century:
  - Early studies focused on species trials





# Historical Perspective

- Reclamation later in the 20th century:
  - 1967, Indiana 1<sup>st</sup> state to require grading and contouring
  - 1977, SMCRA
  - 1980's, difficulty establishing and maintaining tree plantings
  - Many operators opted to reclaim to "higher and better uses."



*Photo: Tim Taylor*

# Reclaimed mine conditions pre-FRA

Relative importance of site factors different on mined vs. native sites.

- **Compaction**
- **Poor internal drainage**
- **High soluble salt level**
- **Aggressive ground covers**

**Novel Site Conditions**

**Limited species selection**



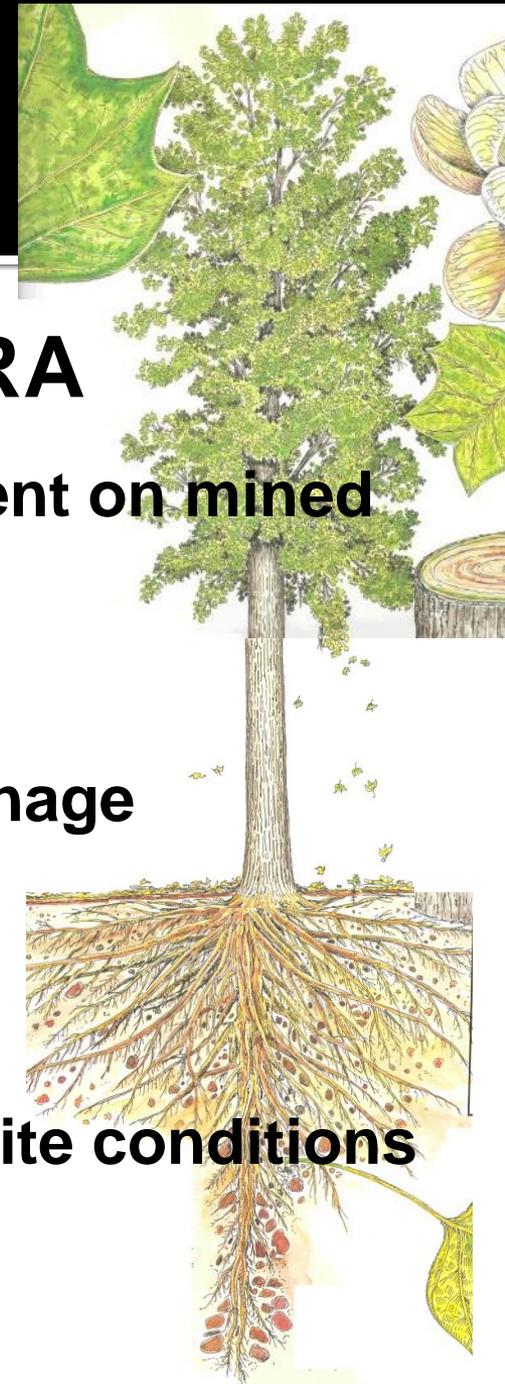
# Reclaimed mine conditions on FRA

Relative importance of site factors different on mined vs. native sites.

- Improved rooting depth
- Improved soil texture and internal drainage
- Optimal pH
- Tree-compatible ground cover

Sometimes improved over prior natural site conditions

Expanded species selection



# Forestry Reclamation Approach (FRA)

**4. Plant two types of trees - early succession species for wildlife and soil stability, and commercially valuable crop trees**

# Species Selection Factors

- **Bond release**
- **Site/adaptation**
- **Seed Source**
- **Succession**
- **Nurse species**
- **Species compatibility**
- **Landscape considerations**
- **Long-term forest health**
- **Deer**
- **Planting stock availability**
- **Long-term landowner objectives**
- **Exotic species**

# Bond Release

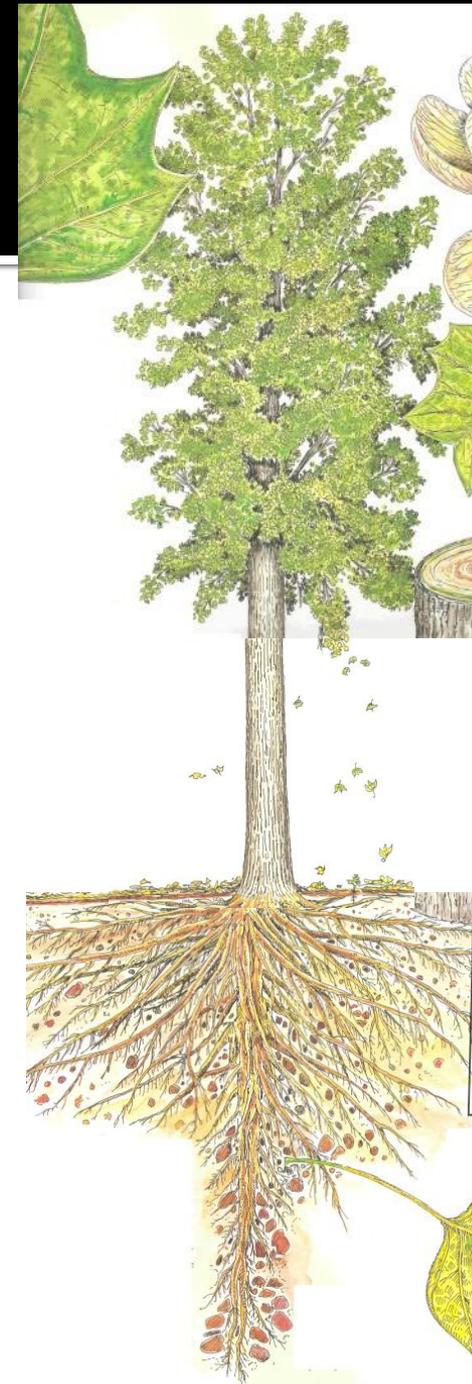
- 450 living trees and shrubs per acre at bond release
- Long term success
  - Healthy stand
  - Acquiring attributes and functions of natural forest
  - Likely to produce wood products
  - Likely to produce environmental amenities ascribed to forest



# Matching Species to Site

## Site

The sum total of the effects of all the factors of a location on the reproduction, establishment, growth, decline, and death of the trees and forest of that location.



## Site Factors

### CLIMATE

radiation, air temperature, rainfall, relative humidity, fog, wind, lightening, fire, etc.

### TOPOGRAPHY

physiography, aspect, slope

### SOIL

texture, structure, pH, ground water, temperature, minerals, organic matter, etc.

### BIOTIC FACTORS

associated plants, animals above and below soil, humans

## Factors Directly Available to Trees

### LIGHT

As source of energy for photosynthesis

### HEAT

As energy for metabolic processes

### WATER

Maintains cell function, component in photosynthesis, and transports nutrients

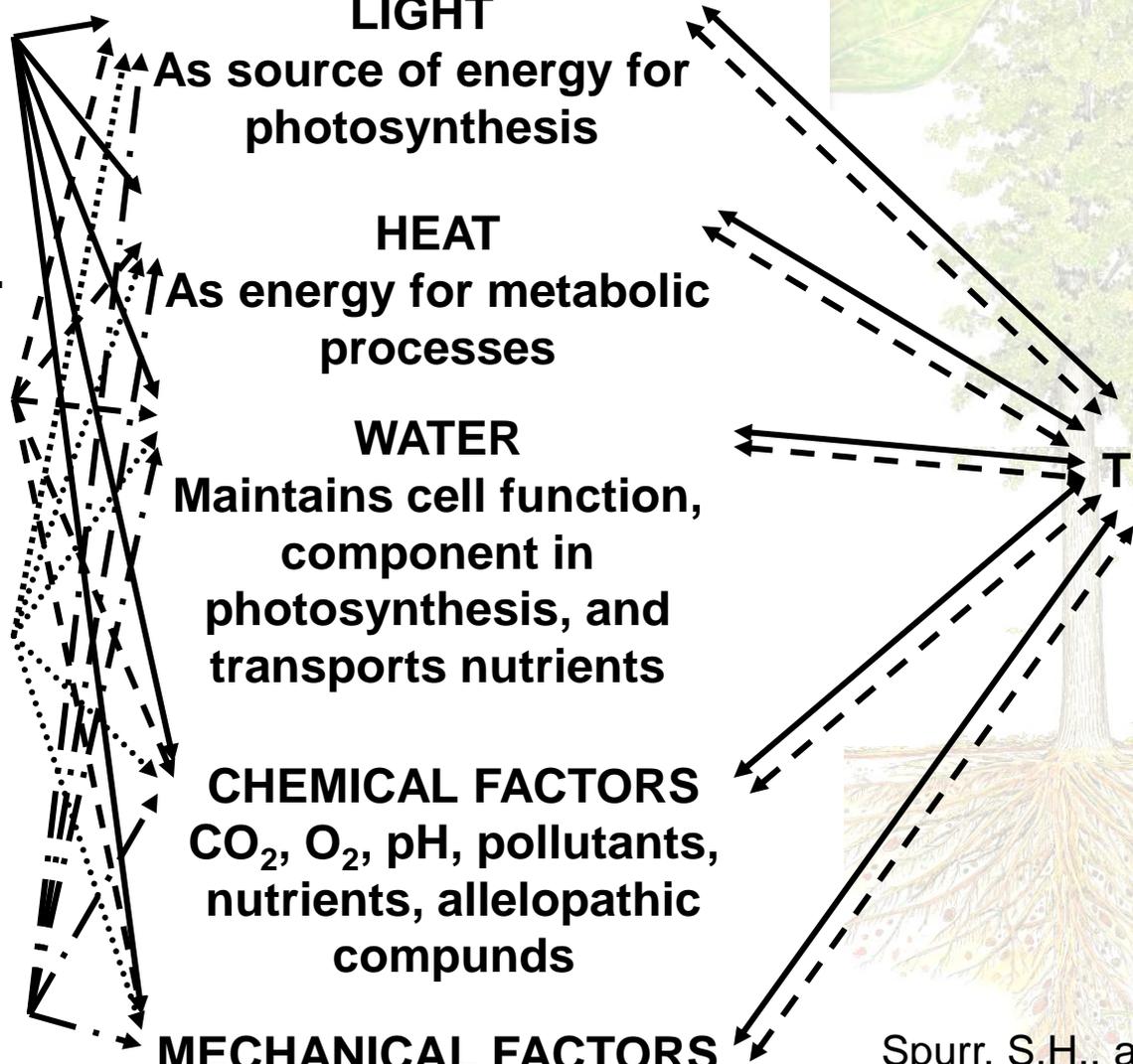
### CHEMICAL FACTORS

CO<sub>2</sub>, O<sub>2</sub>, pH, pollutants, nutrients, allelopathic compounds

### MECHANICAL FACTORS

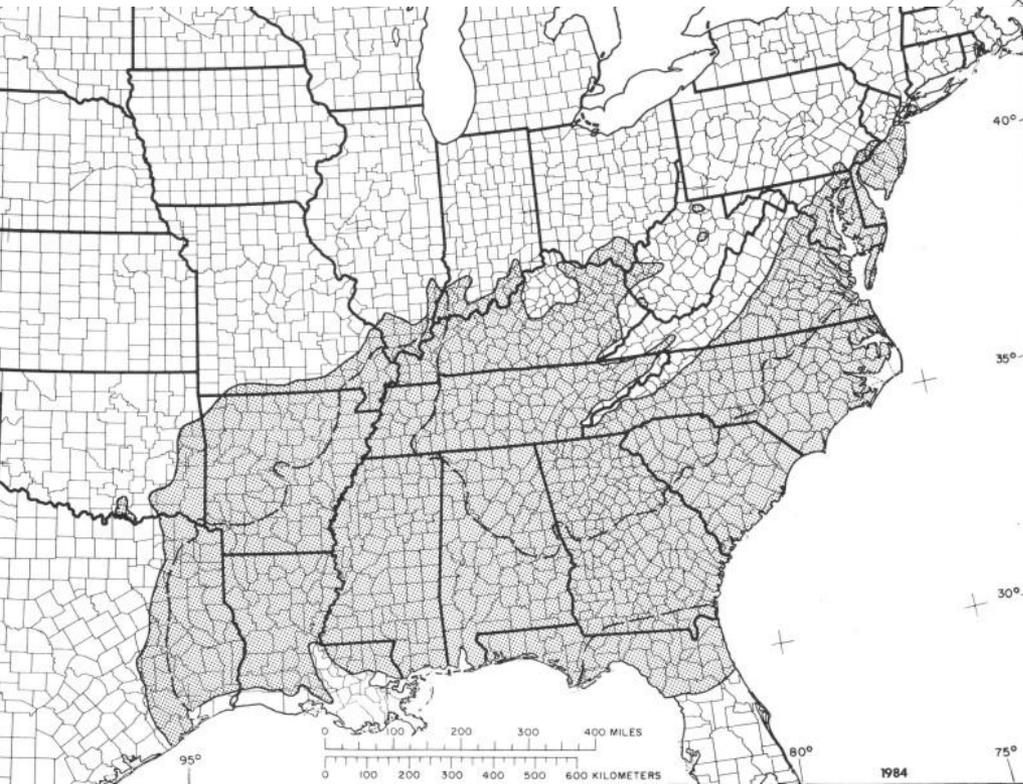
Damage through wind, fire, snow, animals

TREE

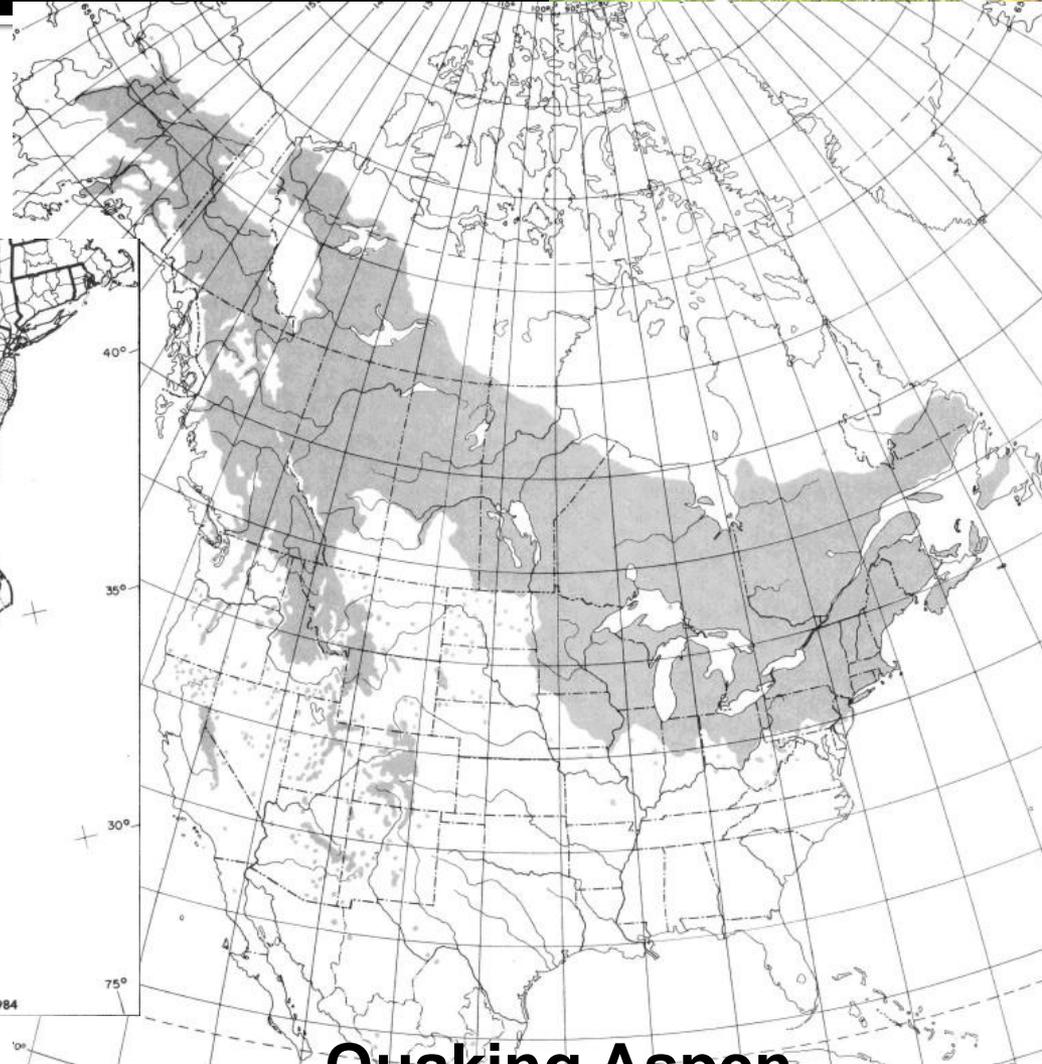


Spurr, S.H., and B.V. Barnes, 1980, *Forest Ecology*, 3<sup>rd</sup> Edition

# Climate



**Southern Red Oak**

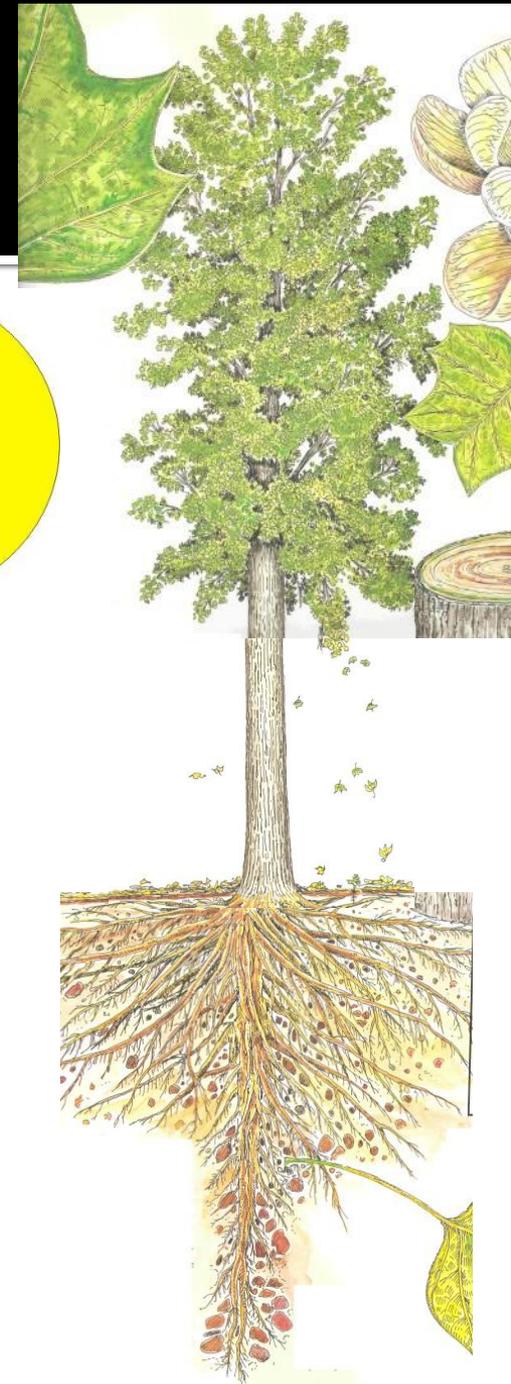
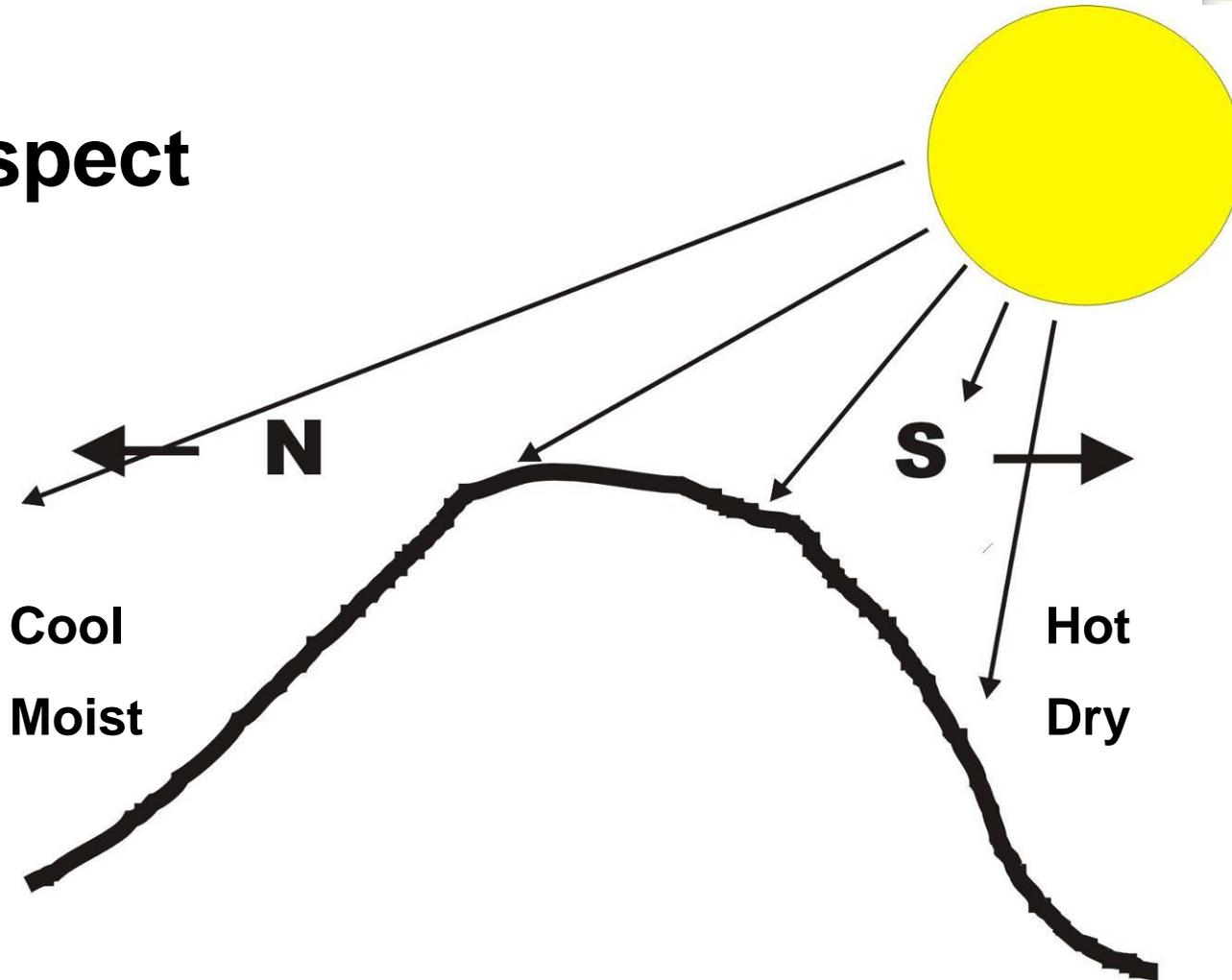


**Quaking Aspen**



# Topography

**Aspect**



# Topography

## Slope

$$\frac{\text{Rise}}{\text{Run}} \times 100 = \% \text{ slope}$$

*low erosion*

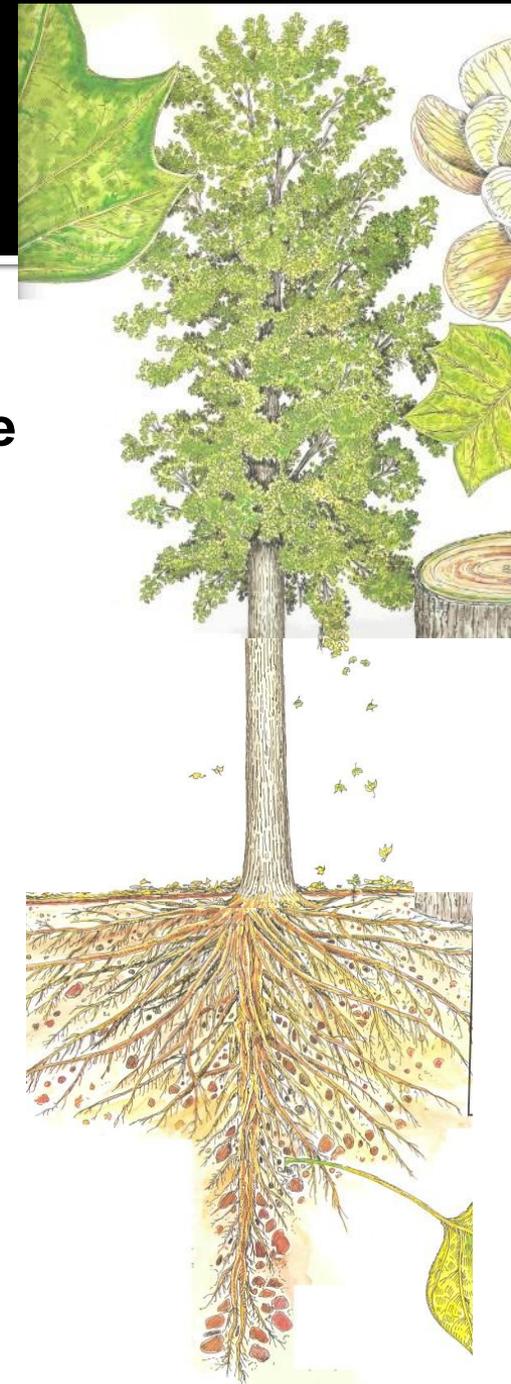
deeper topsoil

more water infiltration

*high erosion*

thinner topsoil

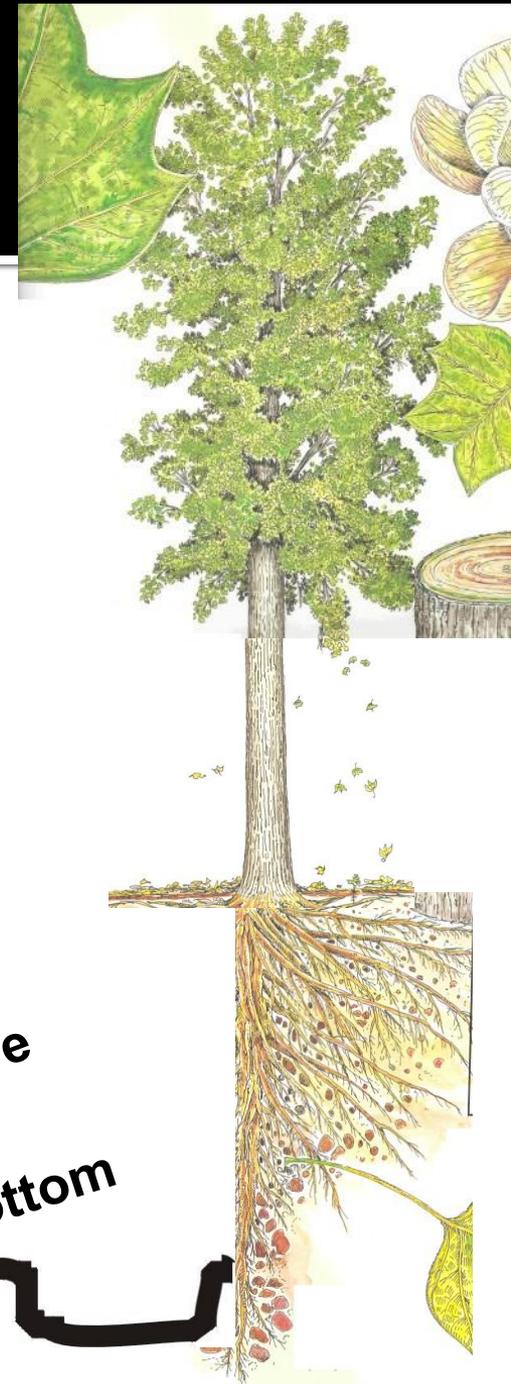
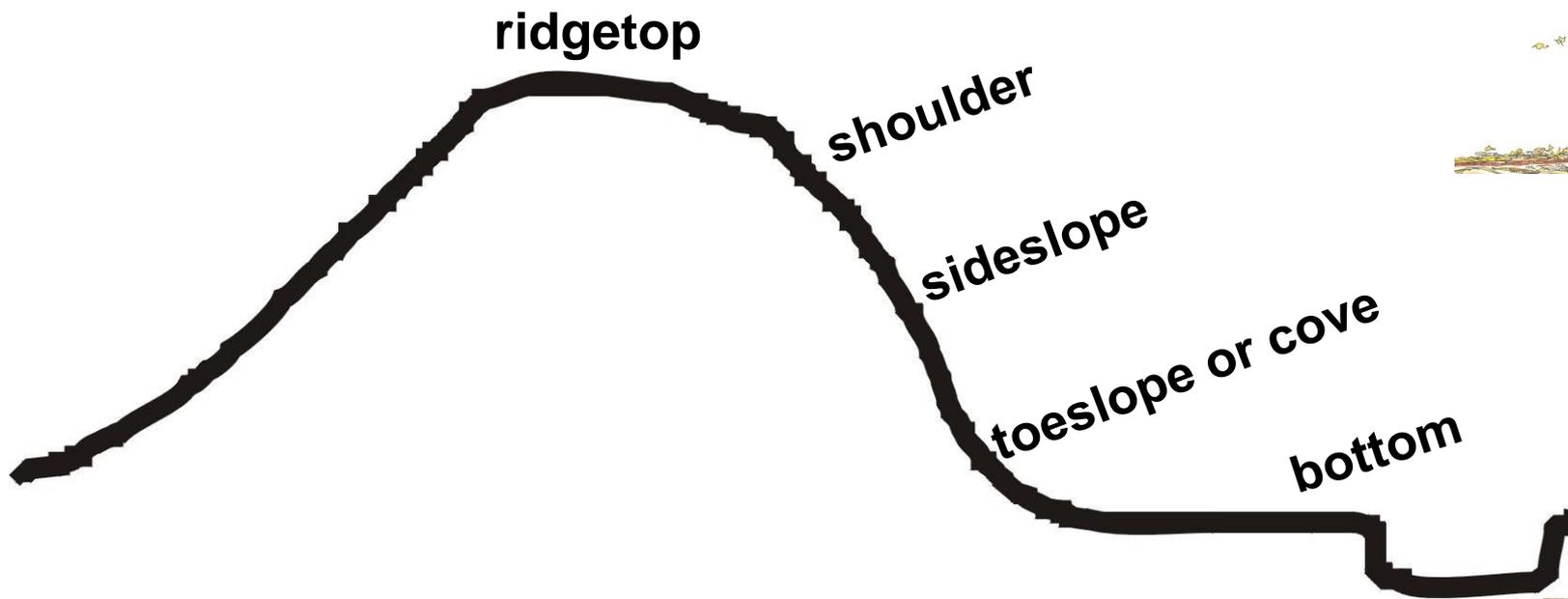
less water infiltration





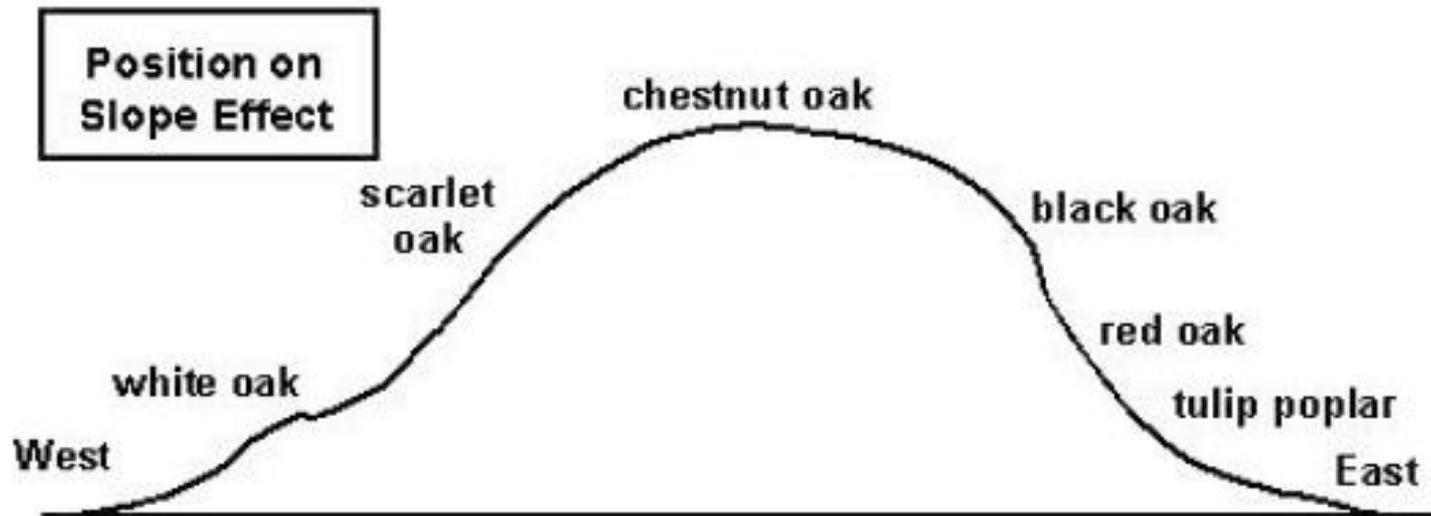
# Topography

## Position



# Topography

## Virginia (southern Appalachia)



Burger and Zipper, Powell River Project, Va. Coop. Ext.

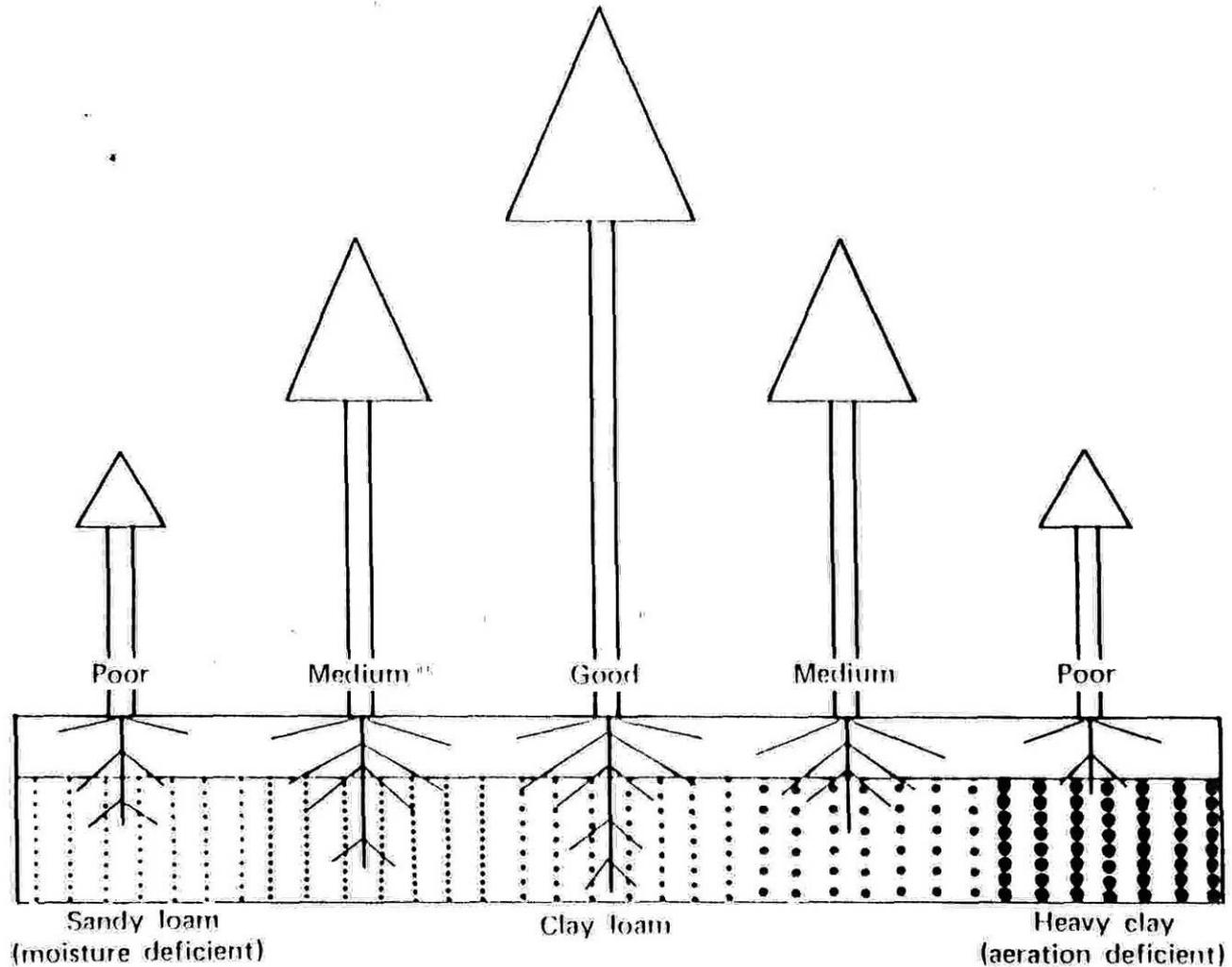
# Soil

## Soil Texture

Sand

Silt

Clay

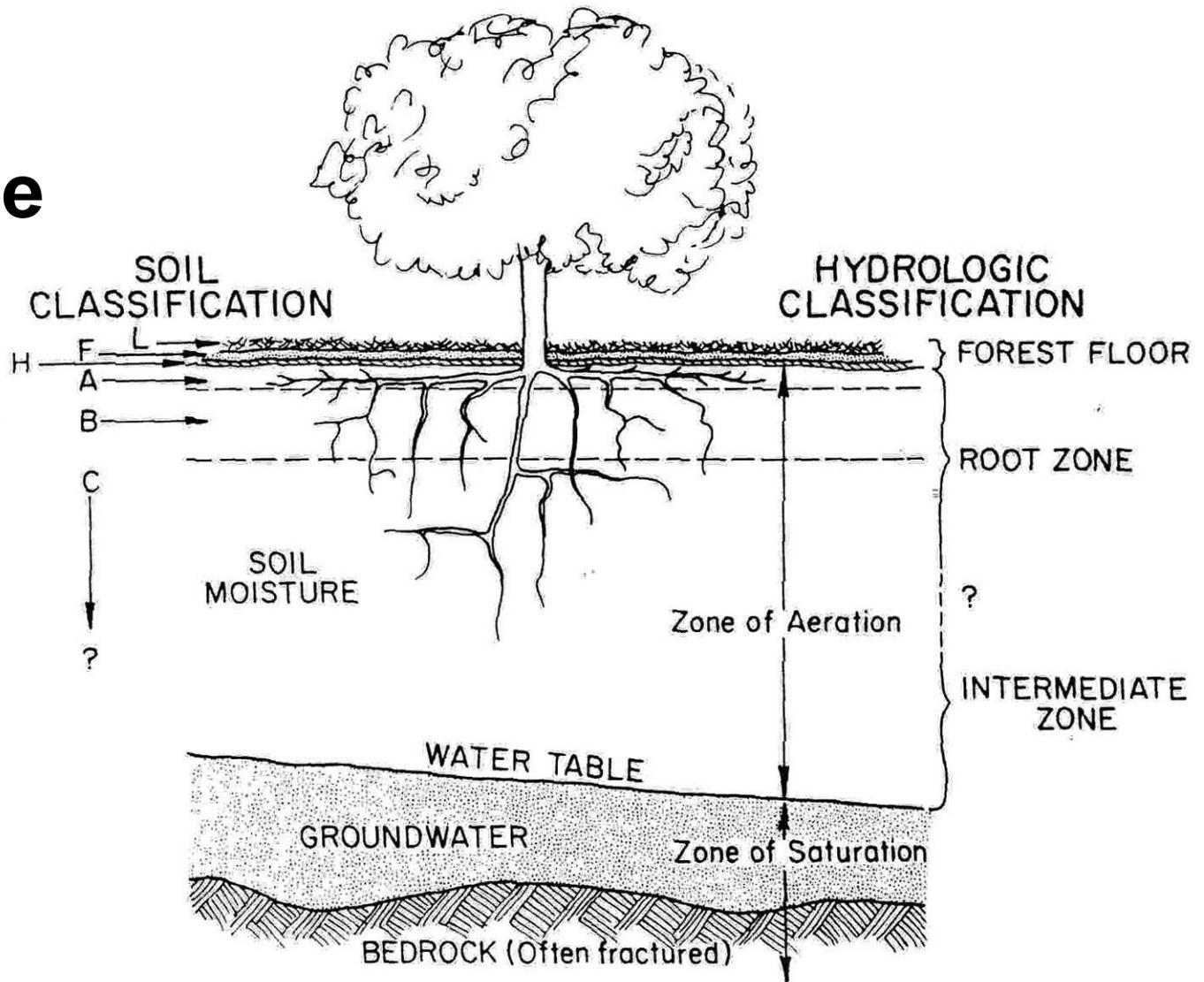


# Soil

## Soil Profile

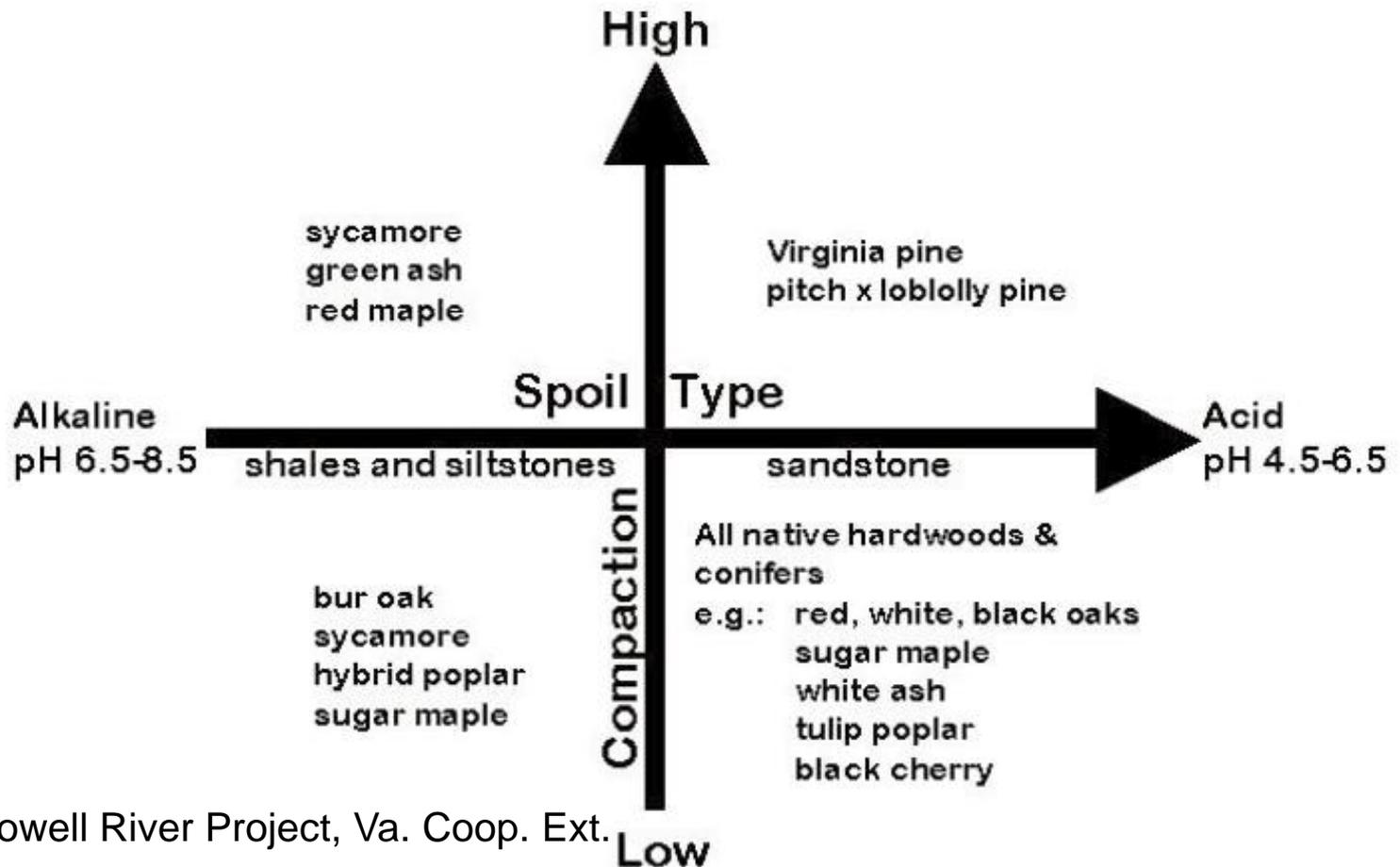
Layers

Depth



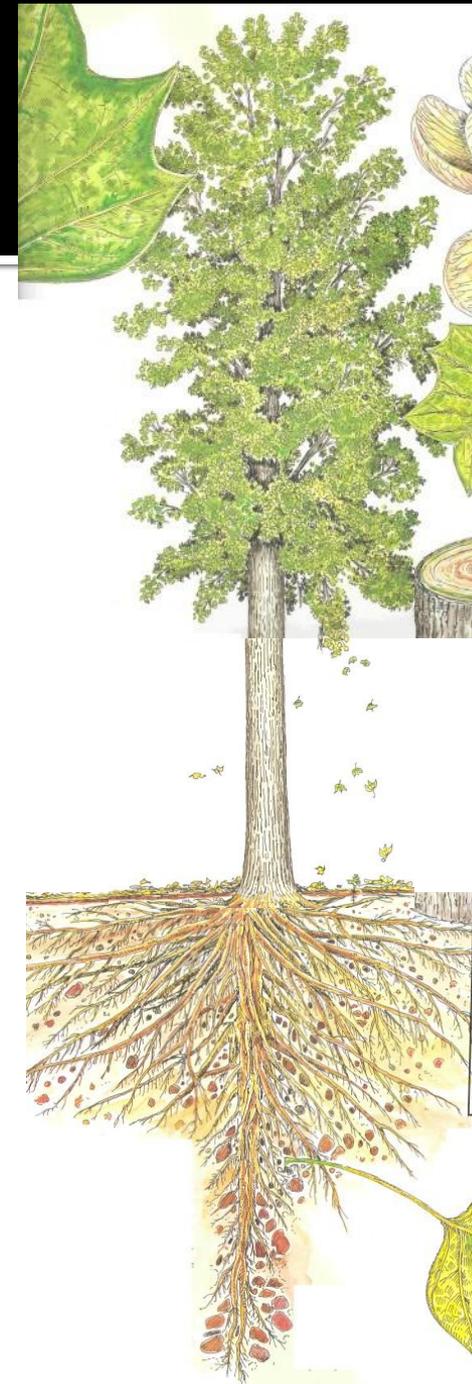
# Soil

## Spoil or Growth Medium



**Site:**

- 1. Dry (xeric)**
- 2. Moist (mesic)**
- 3. Wet (hydric)**



# Site

**Dry (xeric)**

**Limiting factor:**

**Moisture (lack of)**

**Results from:**

- 1. South aspect**
- 2. Shallow and/or sandy soil**

**Forest characterized by:**

- 1. Drought tolerant**
- 2. Slow growth**
- 3. Lower stocking**
- 4. Low quality timber**



# Site

## **Moist (mesic)**

**Limiting factor:  
Light**

**Results from:**

- 1. North aspect**
- 2. Deep, moisture accumulating and retentive soil (not wet)**



# Site

## Moist (mesic)

Forest characterized by:

1. Moisture and nutrient demanding trees
2. Fast growth
3. High stocking
4. Good quality timber



# Site

## **Wet (hydric)**

**Limiting factor:**

**Moisture (too much)**

**Results from:**

- 1. Frequent, semi-permanent, or permanent flooding**
- 2. High water table**
- 3. Restrictive layer**



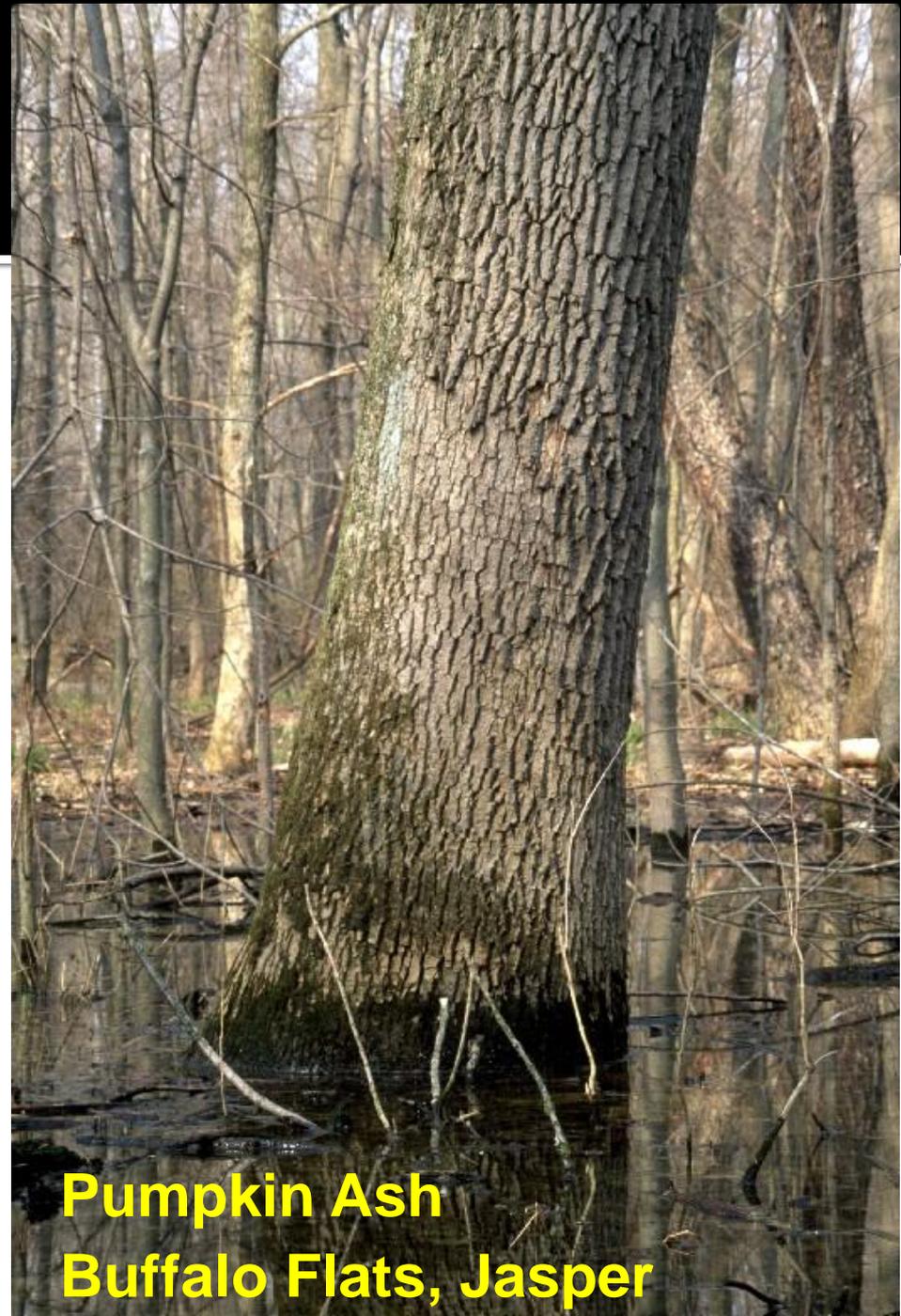
**Patoka River - oxbow**

# Site

## Wet (hydric)

Forest characterized by:

1. Flood tolerant trees
2. Shallow rooted
3. Fast to slow growth
4. High to low stocking
5. Good to poor quality timber



**Pumpkin Ash**  
**Buffalo Flats, Jasper**

Wet Bottomland  
Bottomland Hardwoods

Upland  
Gently Sloping  
N Aspect  
Mixed Hardwood

Upland  
Steep  
S Aspect  
Oak, Hickory

Wet Bottomland  
Bottomland Hardwoods

Upland  
Steep  
N Aspect  
Mixed Hardwoods

Upland  
Moderately Steep  
W to S Aspect  
Oak, Hickory

Upland  
Steep  
W to SW Aspect  
Oak, Hickory

Well Drained Bottomland  
Bottomland Hardwoods

Upland  
Moderately Steep  
N Aspect  
Mixed Hardwood

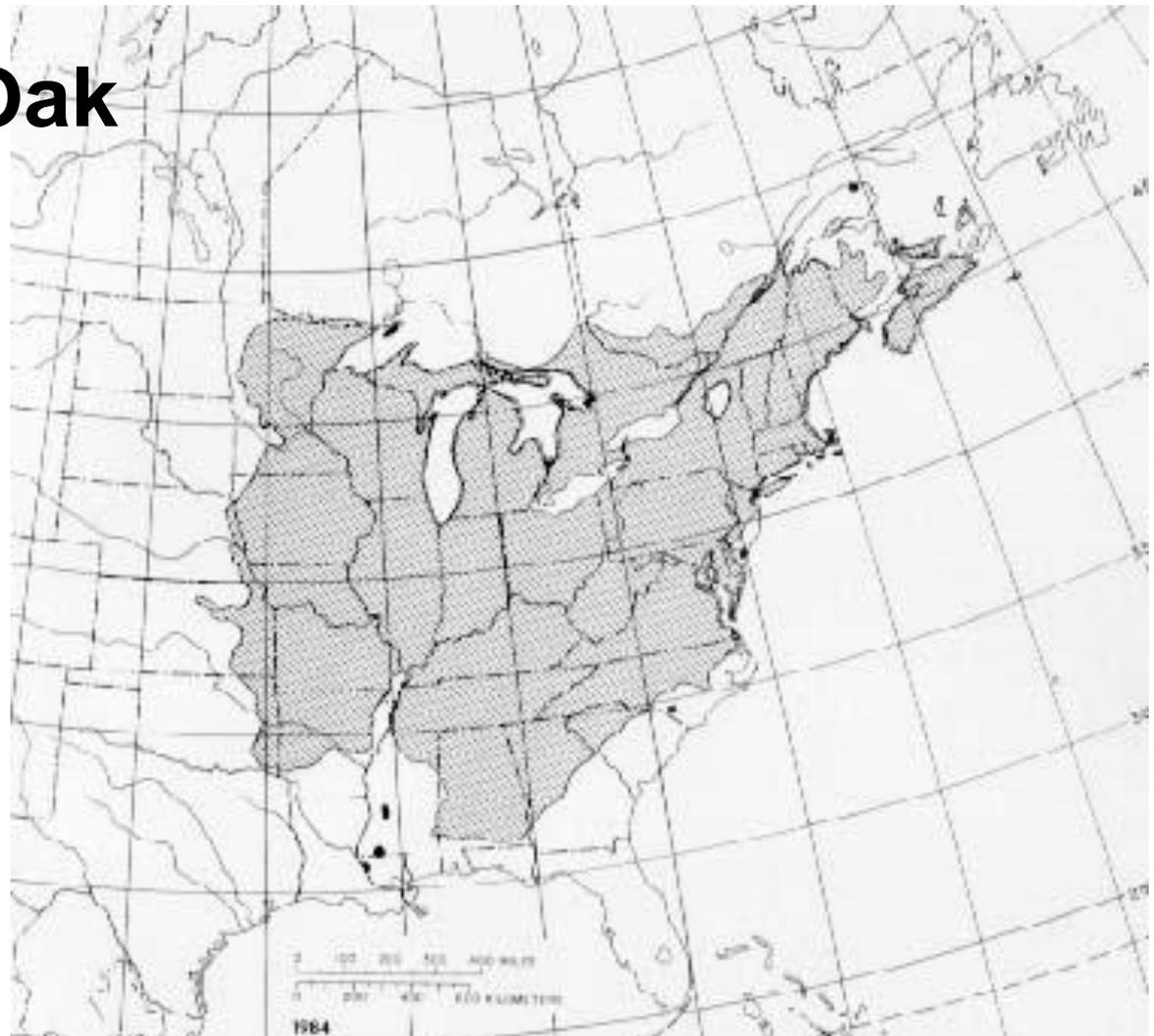
Upland  
Moderately Steep  
NE Aspect  
Mixed Hardwood

# Seed Source

**Northern Red Oak**

**Latitude**

**Elevation**



# Forest Succession

**Three major stages**

**1. Pioneer**

**2. Intermediate/Transitional/Subclimax**

**3. Climax**

# Forest Succession

## Pioneer



# Forest Succession

## Pioneer

### Species Characteristics:

1. Seed light, windblown, waterborn, or transported by birds
2. Require full sunlight – shade intolerant
3. Fast growing
4. Cannot reproduce in own shade



# Forest Succession

**Intermediate (transitional, subclimax)**



# Forest Succession

## Climax

1. Shade tolerant
2. Slower growing
3. Can reproduce in own shade



# Successional Role

Habitat	Pioneer	Transitional	Climax
Dry	Aspen, sassafras, cedar, Virginia pine	Oak, hickory	
Mesic	Many, tulip, cherry, aspen, sassafras	Oak, hickory, ash, elm, walnut	Beech, maple, basswood
Wet (bottomland)	Ash, cottonwood, boxelder, willow, sycamore	Sycamore, silver maple, hackberry, bur oak, swamp white oak, American elm, ash	

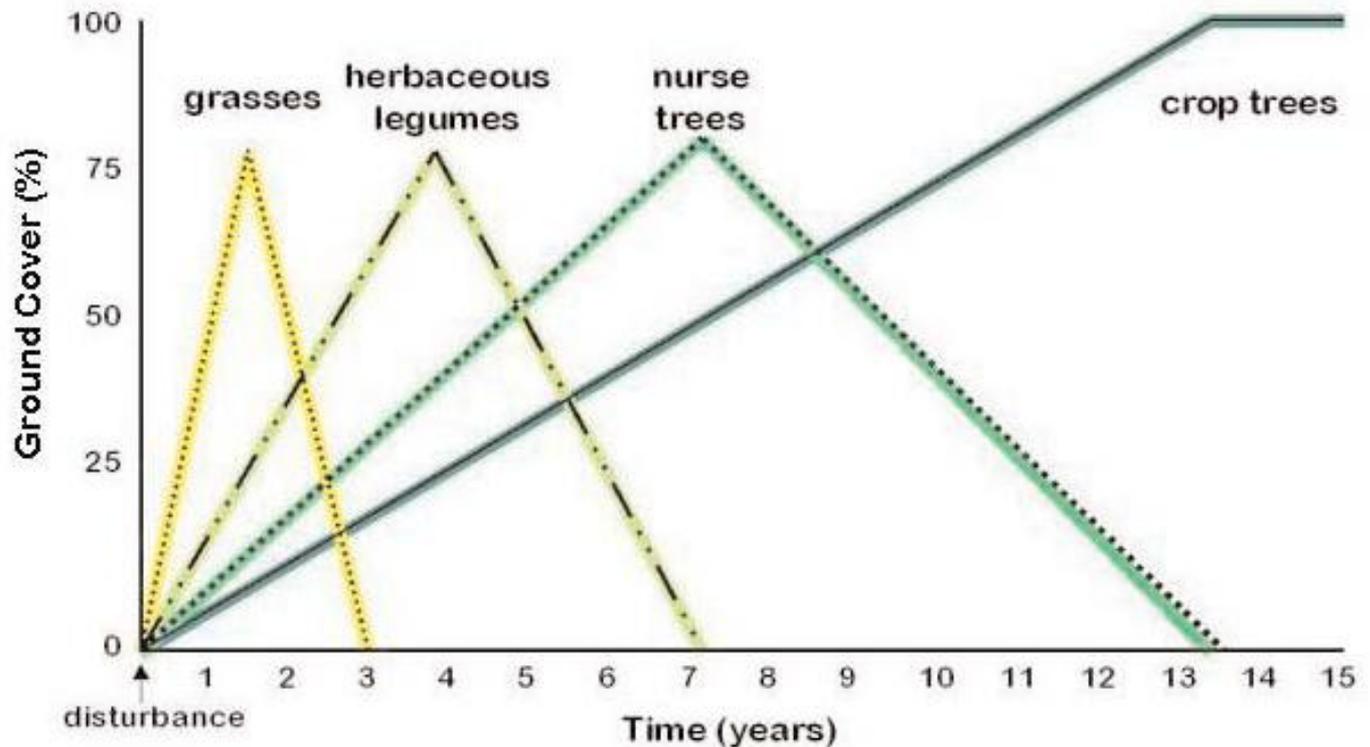
# Forest Succession

## Accelerate Succession

Land stabilization  
and erosion  
control

Bond release

Economic  
returns to land  
owner



Burger and Zipper, Powell River Project, Va. Coop. Ext.

# Nurse Species

**Improve site conditions and crop tree growth and quality**

**N - fixing**

**Shade/cooling**

**Train**

**Contribute to bond  
release**

**Early successional**

**Compatible with  
crop trees**

**Wildlife**



# Species Compatibility

**Successional  
status**

**Growth rate**

**Longevity**



# Species Compatibility

## Monocultures vs. Mixed Stands



# Landscape Considerations

## Natural seed sources

Yellow-poplar – 300,000 to 600,000 seed/acre up to 600 feet.

Cottonwood – 48 million seeds on one tree, 100's of feet to miles.

vs.

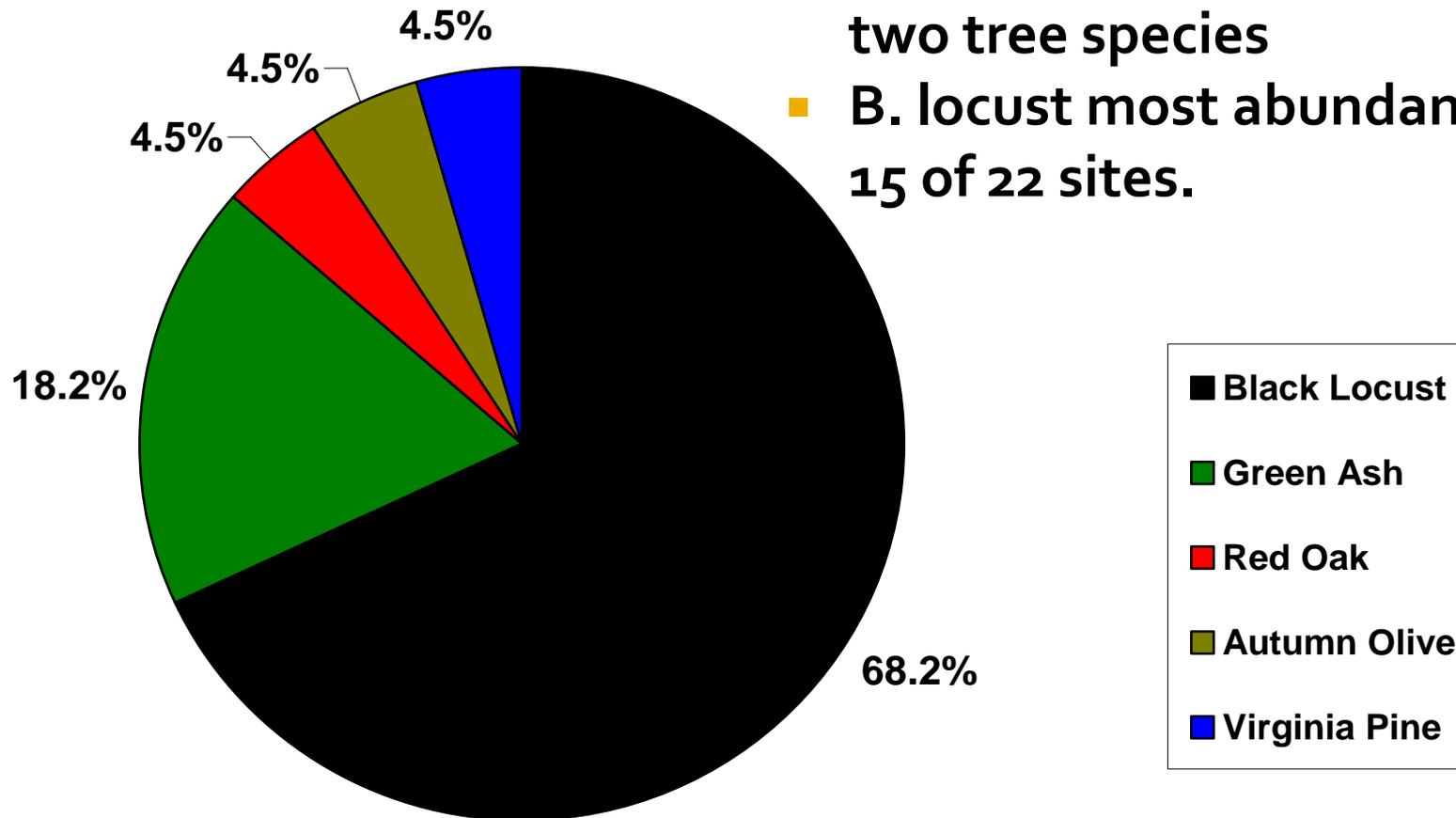
heavy-seeded species



# Forest Health

Indiana mines reclaimed 1988 - 1995

- Over 86% of sites dominated by two tree species
- B. locust most abundant species on 15 of 22 sites.



# Black Locust

Black locust borer  
*Megacyllene robinia*  
Trees under stress  
most susceptible



# Black Locust Dieback



- **Monocultures or single-species dominated stands at greater risk of catastrophic loss and long-term chronic health problems.**
- **In 1999, IN Div. Reclamation issued recommendation to limit black locust to 25% of stand stocking.**

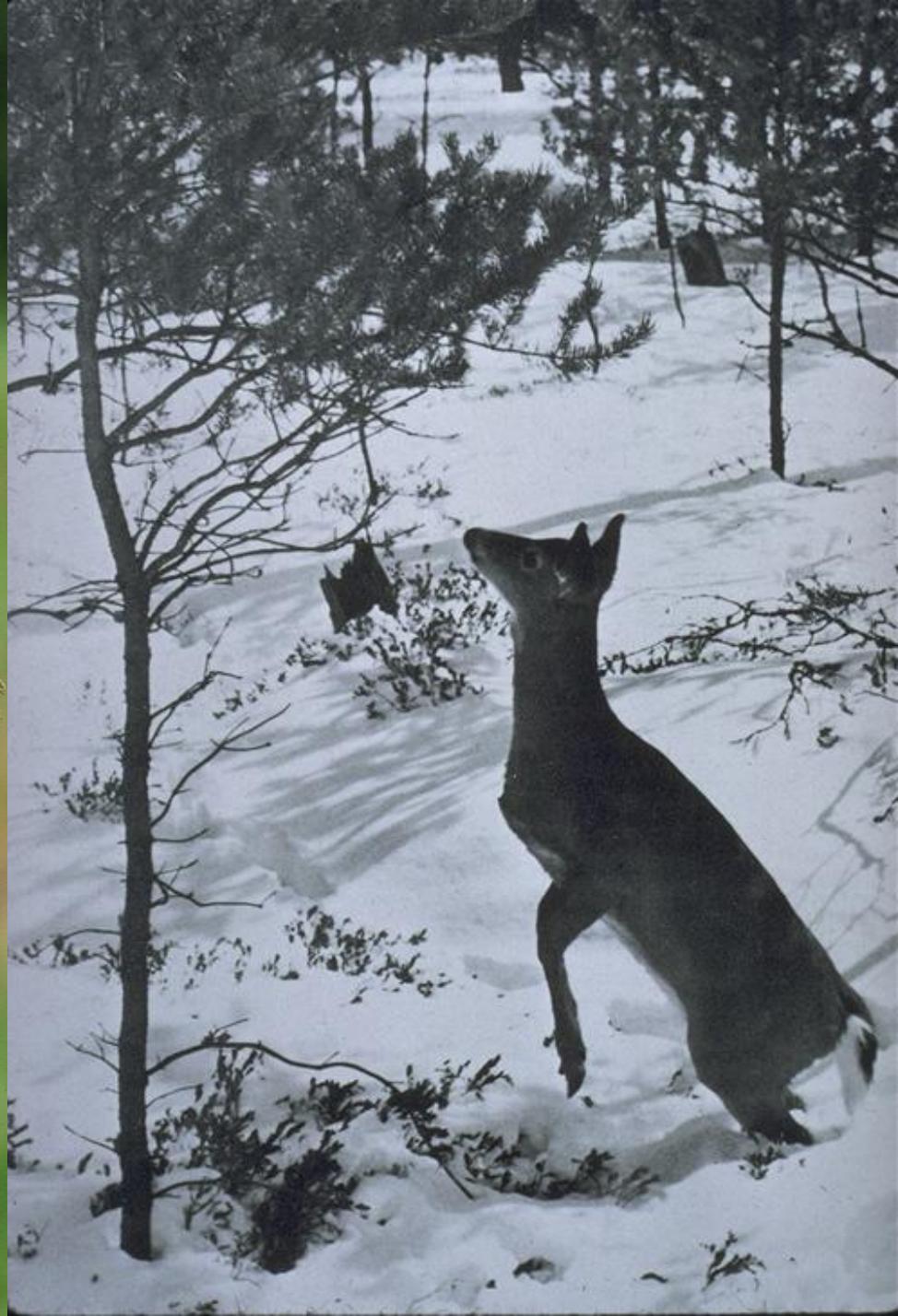
# Green Ash

## Emerald Ash Borer



Deer

Oak –  
Yum, Yum!





# Landowner Objectives

**Contribute to local economy**  
**Community and environmental asset**



# Exotics

Invasive threat!



# General Prescriptions

**Region:** Midwest coal fields (The Illinois Coal Basin located in southern Indiana, southern Illinois, and western Kentucky)

**Site Type:** Moderately to steeply sloped upland

Forest Types	Long Term Benefits	Primary Forest Canopy Species	Secondary Forest Canopy Species	Nurse Species	Wildlife Species	Planting Design Considerations
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**Forest Productivity Level:** low to medium (site index: 65 - 70 ft.)      Site Condition: dry to moist  
 Aspect: southeast and northwest; Landscape Position: upper-, mid-, and lower- and slopes; Slope: > 10%; Soil Depth: 2 – 4 ft.; Soil Drainage: well-drained; Soil Texture: sandy loam to silt loam.

Oak-hickory	Woodland wildlife food and cover  Low grade to high grade sawtimber  Carbon sequestration	Oak: black, red, white  Hickory: pignut, shagbark	Oak: bur, chestnut, chinkapin, scarlet  American chestnut black gum red maple yellow-poplar	Pine: Virginia (south), pitch x loblolly hybrid, shortleaf (south), red (north)  bristly locust black locust red cedar	serviceberry American plum Jersey-tea southern blackhaw persimmon flowering dogwood hawthorns crabapple huckleberry blueberry redbud	
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Forest Types	Long Term Benefits	Primary Forest Canopy Species	Secondary Forest Canopy Species	Nurse Species	Wildlife Species	Planting Design Considerations
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**Forest Productivity Level:** high (northern red oak site index > 70 ft.) Site Condition: Moist

Aspect: northwest to east; Landscape Position: lower, concave slopes, coves; Slope: >10%; Soil Depth: > 4 ft.; Soil Drainage: well-drained to moderately well-drained; Soil Texture: loam to silt loam

Mixed oak Poplar-ash-cherry Mixed hardwoods	High grade sawtimber and veneer  Forest wildlife  Carbon sequestration	oak: red, white  yellow-poplar, black cherry, black walnut	oak: black, chinkapin  white ash American chestnut black gum bitternut hickory butternut Kentucky coffee tree maple: red, sugar	Pine: white  black alder bristly locust black locust	hazelnut spicebush hawthorn (native) American plum flowering dogwood gray dogwood blackhaw arrowwood crabapple persimmon redbud	Plant white ash at low rates, < 50 per acre, due to emerald ash borer.  Plant fast growing yellow-poplar, black cherry, and white ash together in blocks separate from slower growing oaks.  Black walnut for timber production should only be planted on the most nutrient rich sites with the deepest, well-drained soils.
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# General Prescriptions

**Region:** Midwest coal fields (The Illinois Coal Basin located in southern Indiana, southern Illinois, and western Kentucky)

**Site Type:** Flat bottomland and riparian

Forest Types	Long Term Benefits	Primary Forest Canopy Species	Secondary Forest Canopy Species	Nurse Species	Wildlife Species	Planting Design Considerations
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**Site Condition:** wet bottomland flat Forest Productivity Level: low

Soil Depth: <2 ft.; Soil Drainage: poorly drained with permanent high water table and seasonal flooding; Soil Texture: silty clay to clay and/or compacted layer within 2 ft.

Hardwood swamps Cypress swamps	Woodland wildlife food and cover Low grade sawtimber, pallet stock, ties, mine props	Oak: overcup swamp white, swamp chestnut, pin	ash: green, pumpkin maple: red, silver sycamore river birch sweet gum baldcypress	cottonwood swamp cottonwood hybrid poplar  black willow honeylocust	buttonbush dogwood: silky, red osier deciduous holly speckled alder shrub willows	Plant ash at low rates, < 50 per acre, due to emerald ash borer. Most bottomland trees and shrubs cannot establish in permanent standing surface water.
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# General Prescriptions

**Region:** Midwest coal fields (The Illinois Coal Basin located in southern Indiana, southern Illinois, and western Kentucky)

**Site Type:** Flat bottomland and riparian

Forest Types	Long Term Benefits	Primary Forest Canopy Species	Secondary Forest Canopy Species	Nurse Species	Wildlife Species	Planting Design Considerations
<b>Site Condition: well-drained bottomland flat</b> Forest Productivity Level: medium to high Soil Depth: > 3 ft.; Soil Drainage: well-drained; Soil Texture: sandy loam to silt loam.						
Bottomland Oak-hickory	High grade sawtimber wildlife	oak: swamp white, swamp chestnut, bur, cherrybark, shumard shellbark hickory	green ash maple: red, silver sycamore river birch sweet gum	cottonwood hybrid poplar black alder black willow honeylocust	hazelnut spicebush hawthorn (native) dogwood: gray, silky, red osier deciduous holly speckled alder elderberry arrowwood ninebark American cranberry bush	An elevation change of 2 – 4 ft. in river bottoms can change the hydrology of the soil from well-drained to wet. These sometimes subtle changes should be noted and species matched accordingly.  Plant green ash at low rates, < 50 per acre, due to emerald ash borer.
Industrial plantation	Carbon sequestration Biomass /bioenergy and pulpmill feedstock	cottonwood hybrid poplar sycamore				

# West Virginia

MOISTURE REGIME				
Wet	Moist - Moderate	Moderate	Moderate - Dry	Dry
1	2	3	4	5
<b>TREES</b>	<b>TREES</b>	<b>TREES</b>	<b>TREES</b>	<b>TREES</b>
White Ash	White Ash	White Ash	White Ash	Black Oak
Yellow Poplar	White Oak	White Oak	White Oak	Chestnut Oak
Sycamore	N. Red Oak	N. Red Oak	Black Oak	Scarlet Oak
Black Willow	Black Cherry	Black Oak	Chestnut Oak	Native Hickories
Black Walnut	Sugar Maple	Black Cherry	Scarlet Oak	Red Maple
Butternut	Yellow Poplar	Sugar Maple	Native Hickories	
Silver Maple	Black Walnut	Yellow Poplar	Black Locust	Norway Spruce
Red Maple	Cucumbertree	Cucumbertree	Big-tooth Aspen	Virginia Pine
American Beech	Basswood	Basswood	Quaking Aspen	
River Birch	Black Locust	Black Walnut	Red Maple	
	Persimmon	Black Locust	Sweet Birch	
Eastern Hemlock	Red Maple	Red Maple	Sweet Gum	
	Butternut	Big-tooth Aspen		
	American Beech	Quaking Aspen	White pine	
	Big-tooth Aspen	Persimmon	Short-leaf Pine	
	Quaking Aspen	Native Hickories	Virginia Pine	
	Sycamore	Sweet Birch	Red Spruce	
	Black Willow	Sweet Gum	Norway Spruce	
	Silver Maple			
	Sweet Birch	White Pine		
	Sweet Gum	Short-leaf Pine		
	River Birch	Norway Spruce		
	White Pine			
	Eastern Hemlock			
<b>SHRUBS</b>	<b>SHRUBS</b>	<b>SHRUBS</b>	<b>SHRUBS</b>	<b>SHRUBS</b>
Black Alder	Black Alder	Flowering Dogwood	Flowering Dogwood	Flowering Dogwood
Willow	Eastern Red Bud	Eastern Redbud	Eastern Redbud	Black Alder
	Red Mulberry	Red Mulberry	Black Alder	Gray Dogwood
	Crab Apple	Black Alder	Crab Apple	
	American Holly	Crab Apple	Gray Dogwood	
	Howarthorn	Gray Dogwood	Howarthorn	

# Stand Stocking

**Understocked**



**Well stocked**

# Field Application

- Map
- Reclamation forester
- Close field supervision

